High resolution X-ray microcalorimeter detectors with multilayer absorbers and multilayer transition-edge sensors

Mark Cunningham
Simon Labov
Matthias Frank
Troy Barbee Jr.
Lawrence Livermore National Laboratory

Microcalorimeter Approach

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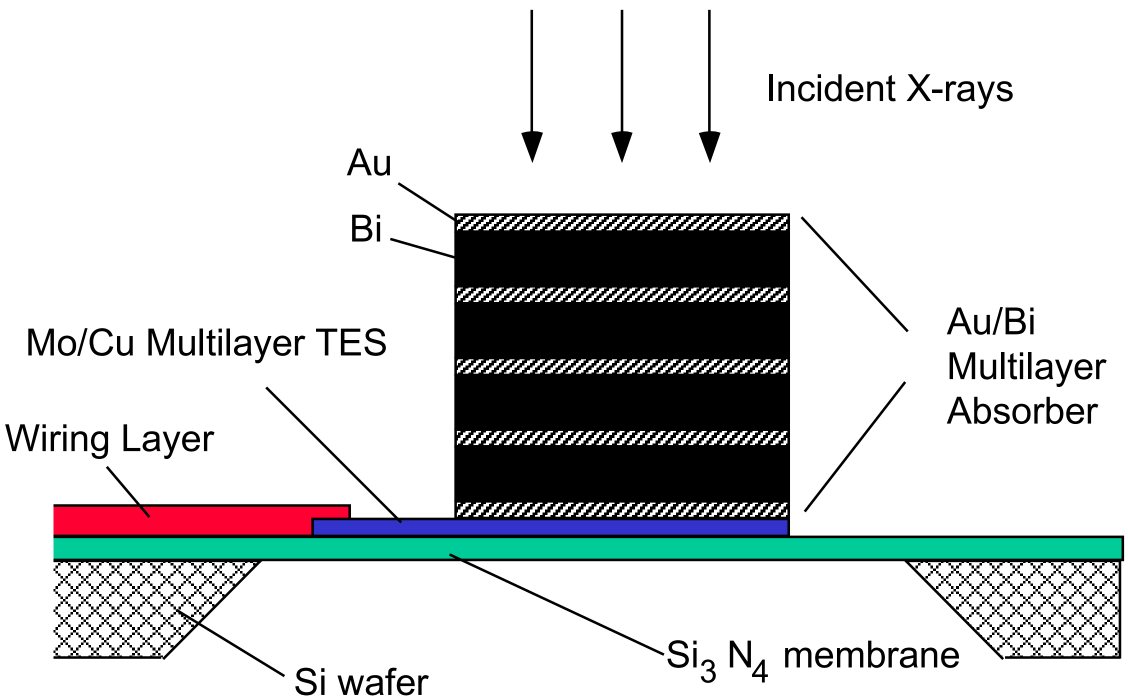
- Au/Bi multilayers are used to absorb X-rays
- Mo/Cu multilayer TESs are used to measure the energy of the X-rays



Mo/Cu multilayer TES

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- Mo and Cu are mutually insoluble
  - Mo/Cu can be heated to 400 C to relieve stress
- Superconducting multilayers are very uniform
  - for a sharp transition, the distance between layers should be less than the length scale of the proximity effect
  - bilayers are more limited in the total thickness and resistance
  - thicker films with lower current densities are possible

Mo/Cu multilayers

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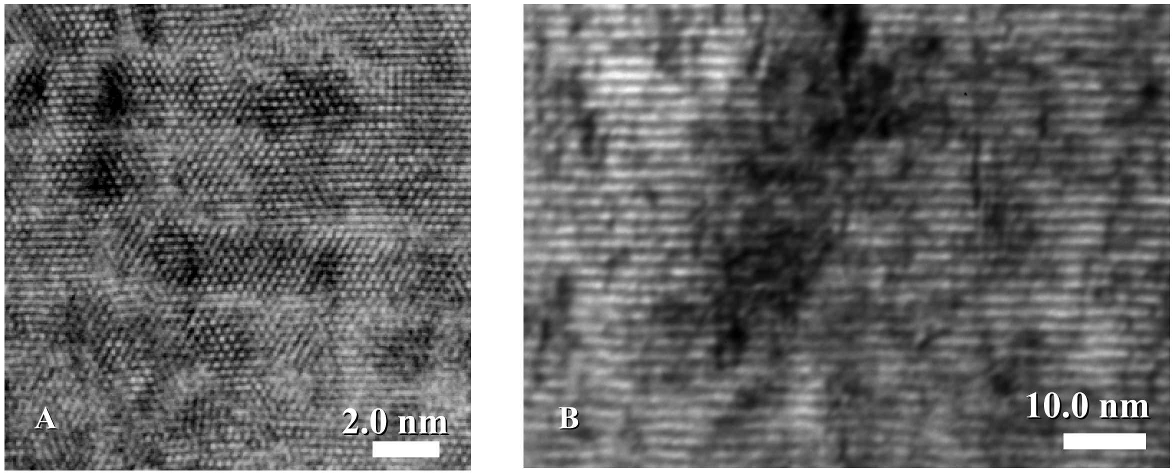

Total thickness = 2500 Å, 115 periods
Each period contains:

Mo: 5 monolayers @ 2.224 Å = 11.12 Å
Cu: 5 monolayers @ 2.087 Å = 10.43 Å

Thickness accuracy ± 0.2 Å
Reproducibility 0.2%

Cooper Limit Model

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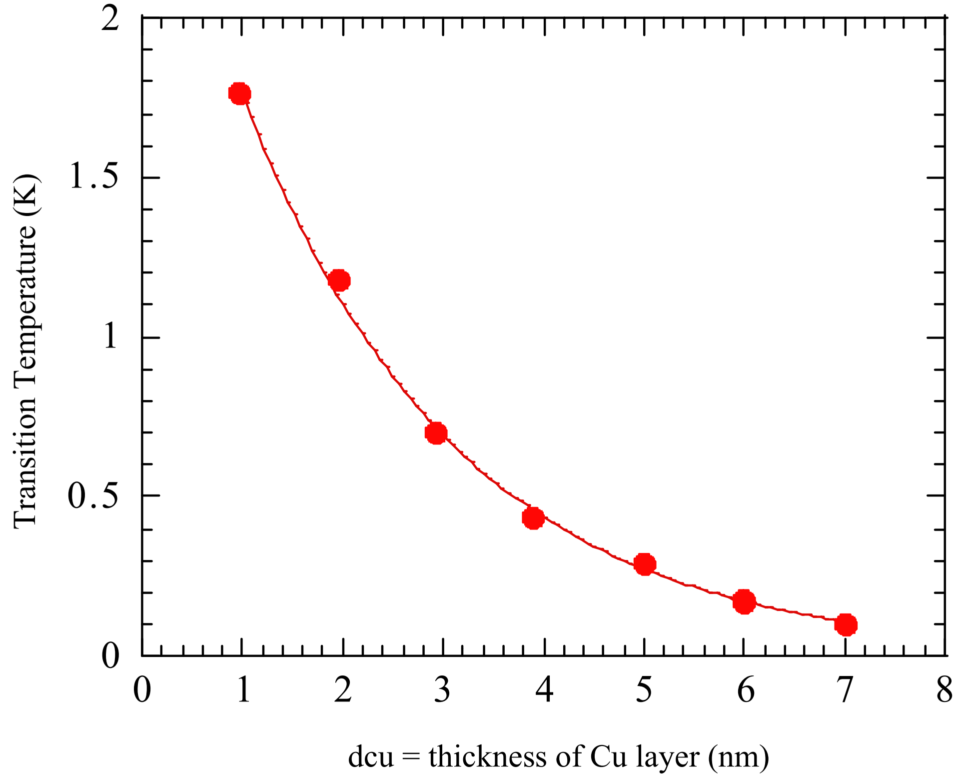
$$Tc = 1.14\theta_D \exp\left(\frac{d\,\mathrm{mo} + B d\,\mathrm{cu}}{-d\,\mathrm{mo} * N(0)\,V}\right)$$

Curve fit using two variables:
N(0)V = 0.19
B = 0.18

Calculated N(0)V=0.15



Tc versus Thickness of TES

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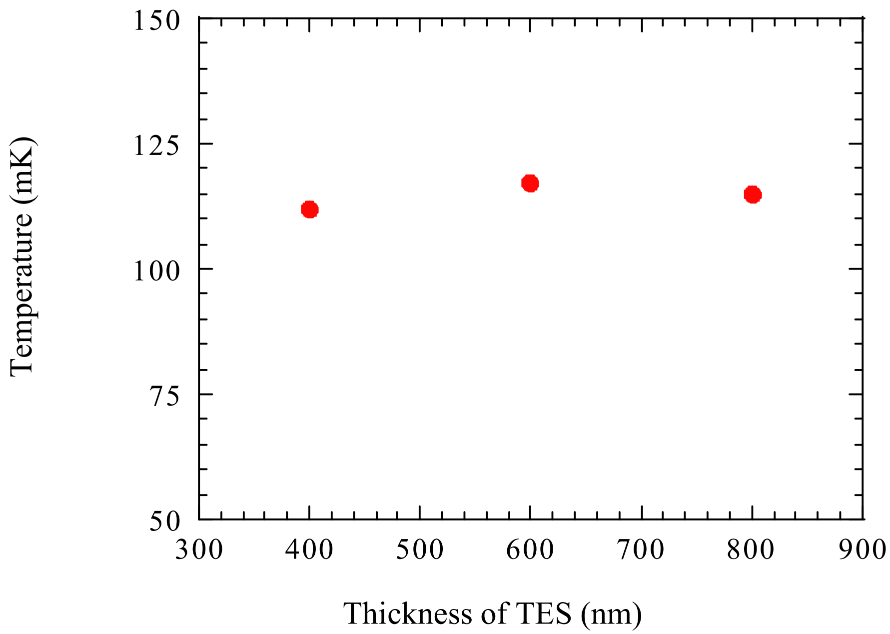

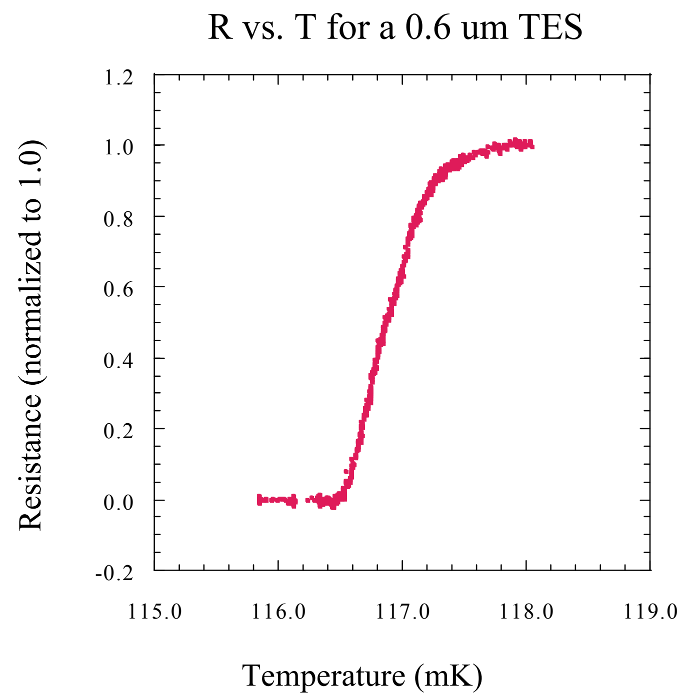

Using multilayers, we can produce smaller pixels without increasing the current density

New Commercial SQUID Arrays

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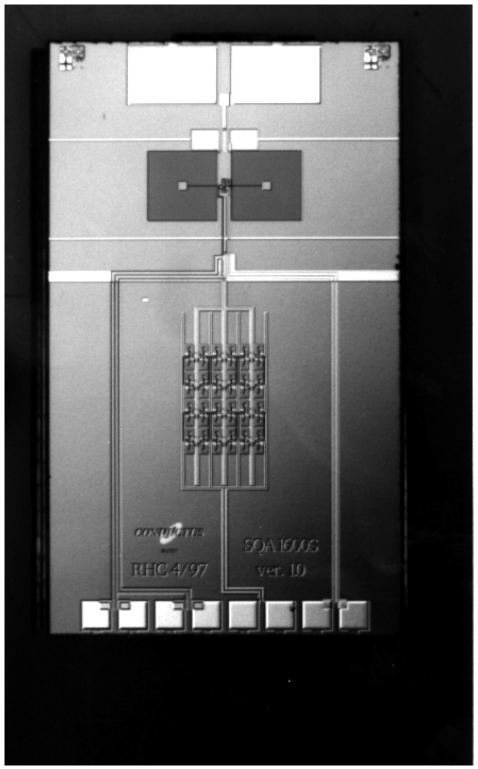

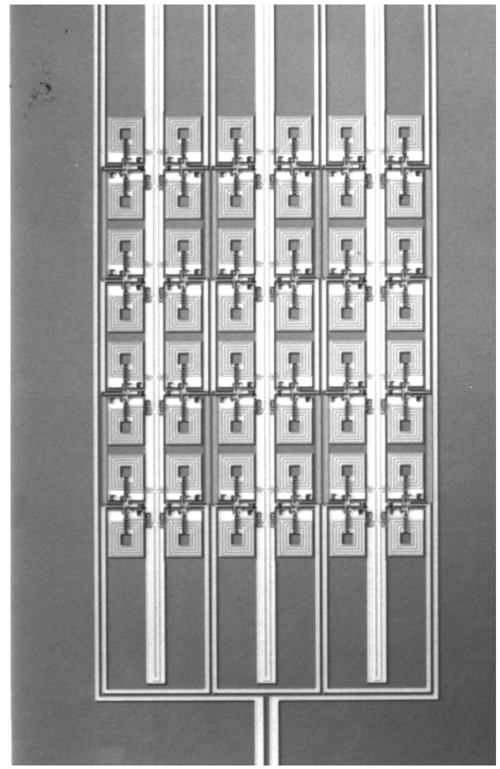

36 Element 2 Stage SQUID developed at Conductus

Noise Measurement of SQUID Array

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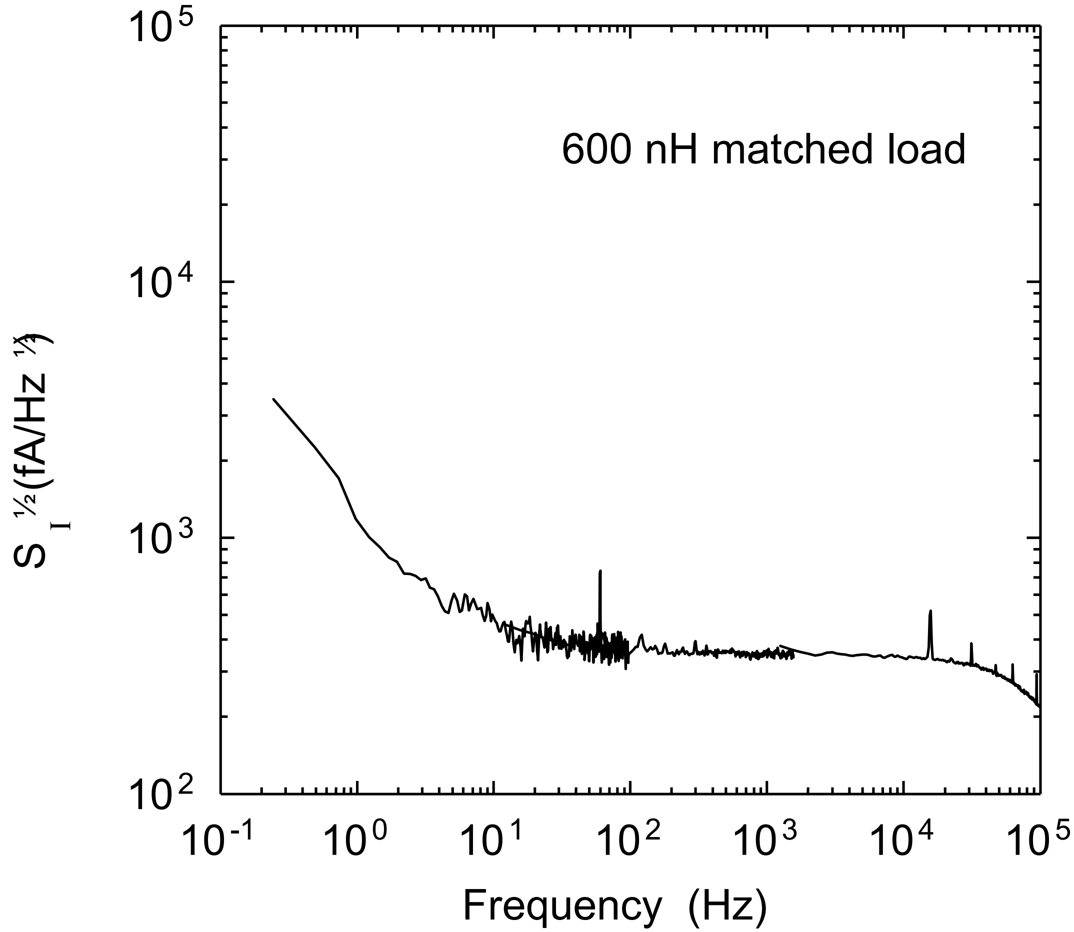

Testing of SQUID Arrays

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- Squid Arrays developed at Conductus
- No spares of sufficient quality available
  from the Conductus Run
- Development continued by Robin Cantor
  at STAR Cryoelectronics
- Test new arrays in a few weeks

Cu/Bi or Au/Bi Multilayer Absorber

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- Advantages of Cu/Bi Absorber
  - Tune Heat Capacity
  - Maintain Good Thermal Conductivity

- Bi Target Ordered

- Work have begun work on a sputtering system that will be used for the deposition of Bi

Summary

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We have measured the properties of Transition Edge Devices

- Tc is constant with total thickness of the film
- Tc versus thickness ratio agrees with Cooper Limit Model
- Transitions widths are typically narrow

We are now investigating

- Stability of Tc with time and cycling
- Transition width control with annealing of samples
- Performance of new commercial SQUID system